TOWARDS A SCIENCE OF COMPUTER GAMES

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ABSTRACT

While the playing of computer games forms a significant part of the lives of our 'Digital Native Youth', there is currently little theory available to understand the experience of gameplay and to inform computer game designers on how best to construct games. This paper proposes to establish a 'Science' of computer games based on elements from philosophy, semiotics and complex system dynamic theory. We discuss gameplay through the lens of situated and embodied cognition, introducing a discussion of affordances, semiotic systems, and provide an interpretation of immersion and flow. The relation of the player to the game environment is considered, and the of narrative to computer games is discussed. Finally, we preset a step towards a unified Science of computer games based on the theory of complex dynamic systems.

KEYWORDS

Computer Games, Situated and Embodied Cognition, Phenomenology, Narratology, Complex Dynamic Systems Theory.

1. INTRODUCTION

Natural Science studies the real world created by the gods and has led to technological advancements. There is as yet no Computer Games Science, the study of virtual worlds created by games designers. This paper aims to take a first step in developing such a science which will both help us to understand these virtual worlds as well as to advance technology, i.e., new computer games (CGs), Immersive Environments and Educational Immersive Environments (Price & Moore, 2009a). Research into CGs can be classified as (i) the ontology of CGs, what computer games are (ii) the effect of CGs on the player, or *gameplay*. Concerning CG ontology, it has been suggested that CGs can be viewed as the last step in the evolution of *media* from text to literature to cinema to games (Lehto, 2009); there is a trans-disciplinary interest from literature and media studies and also cinematography (Atkins 2003). Relatively little attention has been given to the player experience during gameplay (Ermi & Myra 2005), the focus has been on players motivations to play (Bryce & Rutter 2005), moral issues (Consalvo, 2005) and possible negative effects on the player (Gentile et al., 2004).

The essence of a CG *emerges* only through its interactivity in the context of actual gameplay. Here the game rules embedded as computer code emerge as a dynamic process and have an impact on artistic, social and cultural spaces. People play games for the emotional state they induce; the ultimate emotional state is 'fun' (Bartle, 2004). Grodal (2003) identifies CGS as a distinctive medium where perceptions, cognitions and emotions are entwined with first-person actions. Gameplay requires the player to be willing to engage in make-belief through an intentional acceptance of underlying game rules, and a game succeeds when a locus of player-game interaction is established. This is a phenomenological stance and not an aesthetic judgment about player emotions.

Any game science must take into account the debate between game-theorists, 'ludologists' and narratologists. In this debate the relations between text, narrative and CGs have been explored; this debate started in the first issue of the journal *Game Studies* (Aarseth 2001) and continues today. Recently the classical definition of a linear text has been widened to "any object potentially interpretable by someone" (Pozzato 2001) which includes computer games. These issues are discussed in Section 4. In attempting to define a CG Science, this paper discusses computer gameplay (Section 2), the nature of the player (Section 3) and Section 5 presents our theoretical approach to computer games. This is based on a complex dynamic systems (CDS) approach where a spatially-rooted multi-dimensional system (including affordances and semiotics) is built supporting the generation of meaning during gameplay. The phenomenological principle of embodiment is used to situate the player-game interaction, and the notion of 'gameplay time' as a virtual time is developed. We aim not only to provide an understanding of CGs and tools to analyze CGs but also to produce principles for the design of computer games.

2. GAMEPLAY

The concepts of 'game' and 'play' must first be addressed. Tell a group of children to play in an adventure playground; they will at first run around and explore the equipment, having 'fun', even though there is no predetermined 'game'. But a game may *emerge* when the children spontaneously form two teams and fight mock battles using guns (boys) or words (girls). They may then develop rules, such as the location of safe places, the number of allowable 'lives'. Also a 'goal' may emerge, such as capturing a key hostage. With these rules and goal in place, play becomes gameplay. In other words, gameplay is not necessarily prescribed, it can be invented. We assert that 'meaningful play' (cite S&Z) is an emergent phenomenon and is therefore amenable to the tools of CDS. As in this example (recently witnessed by the authors, Butlins, Minehead, 2009), most games are competitive and involve *conflict* and its resolution. There are very few games, such as the 'detective game' which are fully collaborative.

2.1 Situated and Embodied Cognition

Previously, cognitive science focused on information and mental processing, cognition was understood to be internal symbol processing with associated behavioral responses, rather like a digital computer programme (e.g. Pylshyn, 1990). Recently there has been a shift of focus to acknowledge that cognition is both social and *situated* within the surrounding environment (Clark 1997), (Semin & Smith, 2008). Cognition is then viewed as a *dynamic* process, through interacting with the external environment cognition emerges over time (Clancey, 1997; Clark, 1997). Furthermore the dualistic viewpoint (which separates mind and body) has been challenged asserting that body and mind are mutually interactive (Varela et al., 1991). In this *embodied cognition* model, cognitive mechanisms are directly bound to sensorimotor activity (Maturana & Varela 1987), (Niedenthal et al. 2005). A player becomes embodied through using the computer interface e.g. the un-natural mouse and keyboard actions (as compared with specially designed consoles) in order to navigate the game. Like the use of a mechanical tool, this interface becomes absorbed into the body's perception-action system, extending our body's functionality and allowing us to pay attention to other aspects of the game (Hirose & Ziemke, 2002). Studies have indicated that perception and action are strongly bound with human cognition (Lakoff & Johnson, 1980). Situated and embodied cognition provide a promising framework for understanding gameplay, since this involves the use of mind and body as well as the mechanical interactive game environment (Salen & Zimmerman, 2004). We suggest two important factors in understanding situated and embodied cognition in CGs: First that the player's construction of meaning and experience of causality lies in the relationship between the player's actions and the game environment, and second that *ordered behavior* of players and NPCs emerges according to the self-organizing phenomenology of a CDS. This extends beyond the individual player; in multi-player games, the dynamics of gameplay serves to define an embracing social unit which focuses the allowed actions within the unit (Clark, 1996). We suggest that the formation of a social unit of play may lead to the emergence of a new perception-action system leading to a new expression of play.

2.2 Affordances

In Gibson's (1979) *ecological* view of cognition, perception is a *process* where all necessary information is located in the environment. This information is referred to as *affordances*, elements which are directly perceived without any cognitive effort. These psychological affordances, "opportunities for action that objects, events or places provide for the [player]" (Hirose, 2002) map directly onto CG affordances which are placed into the CG by the game designer. The actions of the player in the game follow directly as a result from these affordances. An example of a CG affordance is a door, which invites the action of walking through it. The player may not perceive this affordance or may even receive misinformation such as from a closed glass door which will result in a collision. Gaver (1991) elaborates on the concept of affordance, while he reasserts that these are the fundamental elements of perception, he distinguishes between the affordance and the information it contains. Affordances gain perceptuality by displaying attributes which suggest corresponding actions, a door-handle displays the action it expects. Note that affordances are not *signs* taken in the *semiotic* sense, since they are directly perceived and require no cognitive mediation. From the perspective of a CG designer affordances provide a tool to embed a substrate for *meaning-making* within the CG by a judicious selection of game objects. Affordances are not abstract, they *exist* as relations between the player and the CG, they are not a cognitive construct, they have the potential to be detected and acted upon by the player with a history of experience.

The literature contains examples where the concept of affordance has been misinterpreted. Norman (1988) introduced the concept of "perceived affordances" which has been taken up by others such as Cooper (1995, in Torenvliet, 2003) who sees affordances as 'what we think' CG objects can do rather than what they can actually do. This runs contrary to Gibson's intention, and asserts the need for cognitive processing rather than direct perception. We suggest that Cooper has morphed the concept of an affordance into the concept of the *semiotic sign* which when perceived must be interpreted. A good example is the keyboard arrow keys. Each key (up, down, left, right) has the affordance of 'pushable', but the action of each key is a function of its sign (up, down, left, right) rather than its affordance. Another misinterpretation has arisen in the context of socially structured ways of understanding, where it is suggested that affordances have to be negotiated since they are "relevant to a certain group in a certain situation" (Linderoth et al.). Linderoth may have a point in the need for players to disentangle relevant information from 'decorations', but again this concerns the game semiotics and not game affordances.

2.3 Semiotics

Playing a computer game involves the creation of meaning, a process of discovering the game rules. On opening a new game, players do not read the 'manual'; they enter the game and discover the rules by experiencing the game. This implies that the CG must be stuffed with signs which engage cognitive processing as well as the direct perceptual input provided by affordances. In linguistics, semiotics is concerned with the understanding of *text*, words, sentences or stories. Computer games as an *expressive medium* present some challenges to semioticians, indeed it has been suggested that establishing a semiotics of CGS may be unrealizable (Eskelinen, 2003). There are several issues here. First a literary or filmic text is considered to be *stable* in that it can be experienced several times without its interpretation changing, whereas a CG is *unstable* in that it changes on every instance of play. We do not agree and apply theories of stability within CDS to defuse this issue applying a more complex dynamic approach. Second, traditional 'text' such as novels exist even if they are not read, whereas a CG only exists (it is born) when it is played. Third, CGs are designed to *challenge* the player rather than to invite the reader of a novel to interpret the story. However, there has been a recent interest in textual-semiotic analysis of CGs. Zinna (2004) has investigated electronic writing artifacts including both *hypertext* and CGs. Zinna defines a text as a production of the player, as a consequence of a player action. For the moment, we suggest that a CG can be seen as a *syncretic* text containing several dimensions of expression (text, spoken words, sounds, music, visuals) which contrive to establish meaning, (see e.g. Greimas & Courtes, 1986). We prefer the term *'semiotic system'*, a complex dynamic system of inter-related signs and signifieds which are experienced by the player and through which 'meaningful play' emerges. The CG designer must be aware of both the activity of play and cognitive processes of *meaning making*, facilitating the player's perception of CG affordances and interpretation of CG semiotics.

2.4 Immersion and Flow

A significant quality of CGs is their production of a psychological state of player *immersion*. There are many definitions of immersion including "the state of being absorbed or deeply involved" (Robertson et al., 1997), "a psychological state characterized by perceiving oneself to be enveloped by, included in and interacting with an environment that provides a continuous stream of stimuli and experiences" (Witmer & Singer, 1998). There is also a fallacy that it is primarily the high level of CG graphical fidelity in representing CG worlds that leads to a perception of immersion. This has been debunked by Salen and Zimmerman (2004) who suggest that immersion occurs "through play itself" and not from high-fidelity realism. McMahan (2003) proposes three factors which can lead to a sense of immersion: (i) a match of user expectation with the experienced gameplay, (ii) action-opportunities which have meaning for the player, (iii) a *consistent* game world. Salen and Zimmerman (2004) view immersion as a consequence of the emergence of 'meaningful play' where player actions and outcomes are discernable (the player knows the outcome of his/her action) and integrated (into the total fabric of the game). The recognition of a *game genre* can also establish meaningful player actions, the formation of hypotheses and the player's expectations within that genre (SC-14 8). Immersion into the CG is a first step, just as we may become immersed into a Mondriaan or a movie. In what follows, the player internalizes the perceived frame and its underlying computer code and so may perturb and challenge the game rules and constraints and even introduce 'extra components' through gameplay. The sense of immersion feeds back into the player's *experience*. Immersion within a CG can be contrasted with *identification* in traditional art where a painting, a film or a symphony can only be *received*. One cannot become involved in the structure of a painting nor the action of a film, these are given to be interpreted. A CG requires the action of the player for it to exist and this releases the *closed system* of computer code into an *open system* of experience (Juul, 2005).

This discussion of immersion presented a model of the player's 'state of mind', a static psychological place (or background) in which the player was able to experience 'meaningful play'. This neglects the dimension of *time*. Gameplay involves player time, and the combination of immersion and player time leads to the concept of 'flow'. (Csikszentmihalyi, 1990). Csikszentmihalyi describes the essence of flow as "a centering of attention on a limited stimulus field" . A player in a state of flow has no cognitive space for irrelevant thoughts, such as the passage of real time. Flow is experienced as a consequence of clear goals and feedback, a balance between challenges and player skills. There is an emergent sense of *control*, a fusion of awareness and action, a loss of self-purpose and of real time, and a movement into *autotelic* activity, an activity performed for itself and not for some extraneous reward.

3. THE PLAYER

3.1 The Nature of the Player

The CG player has an ambivalent stance. The player has a role as an *observer* in the gameplay and an *enunciator* within that game (Greimas & Courtes, 1979). The player assumes the roles of a participant and an actor and so takes on both an impersonal point of view with the CG but also a specific embodied cognitive and emotional point of view. With the advent of multi-user immersive environment such as multi-player games and non-performative simulated environments such as *Second Life* the individual is even able to transcend 'loneliness'. In crafting a CG, the CG designer should be aware of the resulting perceptual, cognitive and emotional experiences of the player. It may be true that as a player enters a game he/she may be intent on extending a representation or simulation of their true *Self* or may experience a desire to do this.

3.2 Player versus Avatar

The player's avatar is his/her representation within the CG virtual world, a projection of the *Self* into a desired-self. Both as a signifying and embodied element, the avatar remains personal and encapsulates both self and desired self. It gives the player a subject position within the immersive environment, "a vicarious body through which the player can act as an agent in a fictitional world" (Klyevjer, 2006). The player may have a choice of which avatar to embrace, and so to define his/her relationship with the avatar (Bolter & Grusin, 2000) as well as the *gaze* through the avatarial camera. The use of the 'first-person' gaze as in *Doom, Quake, Unreal Tournament* does not lead to a player-state of empathy. In third-person games such as the action-adventure games *Tomb Raiders, Grand Theft Auto, Gears of War* the player plays a visible avatar, however there is still insufficient detachment (compared with film) to provide an emotional response, especially since the player cannot see their own face. Through the continual confrontation of this third-person avatar in the game, the player is continually reminded (perceptually not existentially) with the duality of the self and its avatar.

Embodied cognition tells us that human cognition is bound to bodily experience. The identification of a player with a game character seems to be related to the physical characteristics of the avatar's body which is manifested as the players *game Ego* (Wilhelmsson, 2006). This is especially true of the 'Wii' game platform which transfers intimate details of the players stance, motion and acceleration into the avatar's representation. Games with major narrative elements capitalize on identification of the player with the game character. The concept of empathy or 'passion' has been highlighted by Fontanille (2001, 2004) who proposes that the construction of passion requires a process starting from sensation, through perception to interpretation. Landowski (2001) argues that a person does not *decode* the passion signs of an Other but rather *feels* these through direct perception. It is the human (therefore avatar) *face* that communicates all passion, and it is this element which is convincingly lacking from CGs. For example, in *Second Life* emotions are communicated through verbal dialogue boxes and mechanical gestures chosen by the player; this requires the player to resort to cognitive skills rather than direct perception, which kills the experiential nature of passion or empathy.

The player's avatar may be conceived as a digital incarnation of the Self which extends the player's own body into the game as an embodiment of the player's engagement with the game while providing the player with a reflection of the player-Self'. The origin of a *player-sense* is consequent on a subjectivity which is best understood through a phenomenological understanding of semiotics (Greimas, 1987). This aligns with the work of Merlau-Ponty who suggests that a subject is not a mind that owns a body, but exists by being a body-in-the-world. The player's perception of his/her location within a CG through an avatar is grounded in the phenomenology of the body (Merlau-Ponty, 1945). The avatar then functions to give the player a subject-position within the virtual world.

4. TEXT AND NARRATIVE

There is a great deal of academic interest in the relationship between computer games and narratology. In her book *Avatars of Story* (2006) Ryan sees classical narratology, as applied to texts, as unsuitable for the analysis of interactive text and computer games and therefore should be extended. The problem is that text is *stable* in the sense that it can evoke the same response on multiple readings, while CGs are *unstable*, different plays produce different experiences. While a book is interpreted as it is *read*, a CG is interpreted as it is *written* by the player. This is a consequence of the CG's *interactivity*. Zinna (2004) sees computer games as potentially containing multiple textualities which are *generated* by gameplay. He also defines interactivity as a suspension of player reflection and an assertion of player action which occurs at "spots" (space-time locations) within the game. We suggest that the narrative emerges through player actions and choices as the player explores the CG's CDS. Aarseth (2004) also suggests that classical narratology is inappropriate, but for a different reason, concerning the direction of time. Reading text implies a backward looking dimension of time, while gameplay is forward looking as the player pursues a goal. Jenkins (2004) suggests that we should view game designers "less as storytellers and more of narrative architects". To this end Jenkins distinguishes between micro and macro narratives. A macro-narrative is a large structure which defines the main characters and the story's plot. Micro-narratives can be seen as islands of narration within the plot, such as sub-quests, finding different ways to achieve a goal. Even though, as Jenkins notes "not all games tell stories", we feel that even first-person shooters such as Unreal Tournament (where there is no macro-narrative) do produce micro-narratives. For example when two players or teams engage in combat they are producing a micro-narrative. There is also the concept of the *transmedia narrative* (Jenkins 2006) which aims to situate narrative within CGs. The *Jedi Knight* CG series uses previous player experience and narratives in conjunction with the Star Wars film series to produce a consistent overarching narrative structure. Another approach suggested by Ferri (2007) and Meneghelli (2007) is the semiotic device known as the *interactive matrix*. This is a system of all figurative, semantic and ludic resources (such as goals and victory-conditions) needed for the game and which produces a different game text each time the player plays the game. Finally, from a phenomenological perspective, the meaning of a videoludic text is a function of both the player's *experience* and the player's activity or *performance*. The text gains meaning through the first-person experience and his/her performance in the game.

5. A THEORY

The theory we propose is based on Complex Dynamical Systems theory which studies the temporal evolution of interconnected components, especially the emergence of simple patterns of behavior. CDS theory is useful for studying and designing the CG phenomenology which unfolds within the CG ontology which we take as space. We supplement the 3D 'physical' space of the CG with additional abstract 2D strata, such as *affordance, semiotic* and *narrative* strata. Our hypothesis is that during gameplay, a player will move on a *trajectory* through this N-dimensional space (N-space) defined by the strata content and the player's perceptions and actions and so experience 'meaningful play' which may develop into an addiction.

5.1 Self-Organizing Complex Dynamic Systems

This logical N-space of qualities and interactions provides the *form* of the CG. Each and every game object is situated within this space and its purpose is simply to reveal its contribution to the phenomenology of the game. Meaning is generated when the player interacts with the semiotic sub-strata as does the appreciation of *causality*, they are both *emergent* properties of the CDS rather than resulting from the work of the game designer. Through the player's trajectory both meaning and causality assume a phenomenological existence; they are not a cognitive structure in the player's head. The semiotic and affordance strata play a prominent role in establishing trajectories through the N-space. Game objects cannot be separated from the process of experiencing them. Experiences of objects are shaped both by the player's interactions with the objects, but also by their expectations of them. This may vary according to the player, therefore viewed as an *experiential system*. The game experience cannot be prescribed by the game designer, but must emerge through play. Game designers circumvent this issue through the use of 'play testing' in their development lifecycle, where a game under development is subject to iterative evaluation by game players. Game objects have a presence on all strata of our N-space. Each game object should have a use (excluding 'decorations') which is implied as an affordance or deduced from its semiotic sign. The CDS does not provide unidirectional links from affordance or sign to use, but rather a bidirectional one, where the use of the object contributes to the nature of the game rules and gameplay.

What is the mathematical structure of the CDS we propose? Clearly all dynamic game elements (such as players and NPCs) need to be connected, these connections can be reinforcing or inhibiting. Also the magnitude of the connections is important since it specifies a potential hierarchy of interactions. The system should be *stable* in the sense that it damps the effects of perturbations, yet a stable trajectory does not have to be static, it may be periodic though not chaotic. CDS subsume the much simpler 'Cybernetic' systems which comprise a few components where the emphasis is on the processes of negative and positive feedback. These feedback processes are still vital to the construction of CDS and to the understanding of CGs. For example, in *SimCity* where the player earns money to transform the game world, there is a clear positive feedback loop from money, through transformation, which increases the population which generates more money.

The CDS should display *emergent phenomena* of low complexity. For example when players' trajectories lie close (e.g. they are in the same room and a receiving similar semiotic input) their behavior will be similar. If some players inter-personal interactions are set to be reinforcing and others inhibiting, then we shall see the emergence of two or more teams. The magnitude of these interconnections will establish the life-time of the team, weak connection strength will result in a more rapid disbanding re-grouping teams. The emergent formation of teams helps establish meaningful play, and provides the game with new properties; the team can do something else than the individual could do. The N-space has an *affordance* stratum making the game objects purpose apparent, and elicits the corresponding player action. The *semiotic* sub-strata, through player interaction, leads to meaning-making, so that the player learns the function of game objects by using them.

This will also lead to the emergence of *goals* as the game trajectory progresses and stabilizes as well as eliciting meaningful play.

Players will have programmed interactions with the environment which are bi-directional, both player and the game environment can change each other. For example a pacifist-player could change the meaning of games weapons. This interactivity leads to *situated cognition*, where the game environment plays a reciprocal role in cognition. Programmed player-game interactions can produce a semiotic 'contrary relationship' (Greimas, 1987) like a 'figure-ground' relationship which helps define the sense of player-Self. Myers (SA-25) suggests that game dynamics can be seen as a recursive process of 'context-shifting' from figure to ground and it is this recursive process that "micro-levels of disbelief and its willing suspension somehow bootstrap themselves into macro-level realities" (Myers, 1991). We agree and suggest that such a process will emerge as a stable periodic cyclical structure through the N-space. This cycle serves to *entrain* the player, and this entrainment is what makes games so fun and addictive.

5.2 Space and Time

While gameplay occurs in a 3D representation of the physical space of our real world, our N-space augments this representation with abstract strata containing psychological, phenomenological and semiotic concepts which are interlinked through the dynamic trajectories of players, NPCs and other game objects. This reminds us of the architecture of the built environment: Both Kevin Lynch's five elements of urban planning and Tschumi's design of "La Villette" as three overlaid spaces of point, line and area (Price & Moore 2009b) imply a 'stratified' approach. Yet there are a few other points which may be usefully considered. Deleuze and Guattari (1980) introduce a distinction between 'smooth' and 'striated' space. Striated space is a metaphor which describes a spatial *field* containing lines of resistance, hindering or preventing player's movement whereas smooth space does not. Within our N-space constraints or obstacles are learned by the player within the semiotic strata, e.g., the player is warned not to enter a dangerous space by suggestive sounds.

The player's perception of the game-space is grounded in the phenomenology of the body, "our general meaning for having a world" (Merlau-Ponty, 1945). This requires a first-person perspective which acts and interprets in order to give meaning to the Self and the world-space. Our N-space must therefore take into account the nature of the avatar's existence in the physical game-space, through suitable animations, interactions and semiotic-relevant experiences. The notion of space depends on the game genre under consideration. A first person shooter requires a faithful simulation of 3D space including topographical elements such as terrain, rooms, stairs and physics elements such as gravity and friction. A platform game like Tetris does not require this level of detail; here space is purely logical allowing for intersection of shapes.

Phenomenology asserts that the nature of experience is linked to the nature of time. Merlau-Ponty for example deconstructs the notion of the 'present moment' (Merlau-Ponty, 1945, for him time is not a succession of discrete moments; "Time is not a line but a network of intentionalities" (*ibid*). The player's experience of time is manifest as moments of collision between two aspects of intention, the *retrospection* on what has occurred and the *anticipation* of what is to come. Successive collisions in the present lead to *flow* within a game, a time-based experiential flow not situated in linear 'clock' time. This agrees with conclusions from the narrative-ludologist debate, where narratives are backward oriented in time and games are forward oriented. This may help to situate the narrative substrata of our N-space. Retrospection can be aimed at past micro-narratives and may lead to *tactics* within a game, the lack of such previous micro-narratives may lead to improvised *strategies.*

6. CONCLUSION

We propose a model for a Science of Computer Games. This is based on the mathematical theory of Complex Dynamic Systems which takes an abstract space as a game ontology. This 'N-space' extends the 3D space of the computer game with conceptual strata informed by various elements such as affordances, semiotics and narrative. This model is based upon theories of situated and embodied cognition. We have related this theory to analysis of computer games, an understanding of gameplay and have indicated its usefulness to computer game designers.

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